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Effect of rock phosphate, single super phosphate and their mixtures with FYM on yield, quality and nutrient uptake by turmeric (*Curcuma longa* L.) in acid alfisol of Meghalaya

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Abstract

A field experiment was conducted for two years on a P deficient *Typic Hapludalf* of Meghalaya to study the effectiveness of rock phosphate (RP), Single Super Phosphate (SSP) and their mixtures along with FYM on turmeric. Application of P as RP or SSP alone or their mixtures with FYM significantly increased the rhizome yield over control. There was a 50 per cent increase in rhizome yield due to FYM application. Maximum N and P uptake, curcumin content and Phosphorus use efficiency (PUE) were recorded in RP+SSP (1:3) + FYM treatment. Post harvest analysis of soil samples indicated that soil pH was marginally reduced with FYM application while organic carbon, ECEC and available P contents increased.

Key words: acid soils, *Curcuma longa*, curcumin, farmyard mannure, Meghalaya, phosphorus fertilisers, turmeric

Introduction

Turmeric (*Curcuma longa* L.) is the major spice crop of Meghalaya with a very low average yield of 12.9 q ha^{-1} as compared to national average of 39.1 q ha^{-1} (Anonymous 2000). Presence of high exchangeable Al and high P fixing capacity of soil are the most important limiting factors for turmeric production in the highly acidic soils of the state (Verma & Bhatt 2001). Single super phosphate (SSP) is the main phosphatic fertilizer used in Meghalaya, but because of its water soluble nature, P use efficiency (PUE) hardly exceeds 10-15 per cent. Rock phosphate could substitute SSP in these soils as it is water insoluble and releases P gradually to crops. A large number of trials conducted with rock phosphate on different crops in acid soils indicated that mixture of RP with SSP in different proportions was a profitable mechanism of phosphorus management (Dwivedi & Dwivedi 1990; Paliyal *et al.* 1992). Some work has been done on phosphorus management in field crops like maize, groundnut, soybean etc. in soils of North Eastern region (Das *et al.* 1991), but no information is available on P nutrition of turmeric. The present investigation was therefore conducted to study the efficacy of RP, SSP and their mixtures with FYM on yield and quality of turmeric and soil properties in an acid alfisol of Meghalaya.

Materials and methods

Field experiments were conducted during *kharif* 1999 and 2000 on *Typic Hapludalf* at the experimental farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya to study the effect of P sources and FYM on yield, quality and nutrient uptake by turmeric (cv RCT-1). The experimental soil was acidic with pH 4.5, organic carbon 1.3 per cent, available N, P and K, 363.5, 7.0 and 300 kg ha^{-1}, respectively. There were 12 treatments viz. control, 100 kg P_2O_5 ha^{-1} as SSP, RP and combinations of RP+SSP in the ratios of 1:3, 1:1 and 3:1, each applied with and without FYM in a RBD replicated thrice. Turmeric was planted in 2.5 x 1 m^2 beds with a spacing of 30 x 30 cm. Nitrogen and potassium were applied @ 100 kg N and 100 kg K_2O ha^{-1}, respectively. Full dose of P and K and 1/3rd dose of N were applied at the time of planting. Remaining N was applied in two splits each at 45 and 90 days after planting. Rock phosphate contained 12 percent total P whereas the NPK contents in FYM were 0.76, 0.25 and 0.82 per cent, respectively. Rhizome and leaf samples collected at harvest, were analysed for N, P and K contents by micro-Kjeldahl, vanado-molybdate yellow colour and flame photometric methods, respectively (Jackson 1973). Curcumin content in rhizomes was extracted in absolute alcohol by Soxhlet extraction and estimated colorimetrically (Sadasivam & Manickam 1992). Post harvest soil samples were collected and analysed for pH, organic carbon (Walkley & Black method) and available P (Bray P2 extraction) by standard procedures (Jackson 1973). Effective cation exchange capacity (ECEC) was calculated as sum of exchangeable Ca, Mg, K and Al. Phosphorus Use Efficiency (PUE) was calculated as:

$$\text{PUE} = \frac{(\text{P uptake in treated plots} - \text{P uptake in control plots}) \times 100}{\text{P added}}$$

Results and discussion

Yield and quality

Phosphorus application as RP and SSP alone or in various combinations applied with FYM significantly increased the dry rhizome yield (Table 1). Maximum rhizome yield (46 q ha^{-1}) was recorded with RP+SSP (1:1) + FYM which was at par with other P treatments applied with FYM. Increase in yield with P application might be due to increased availability of phosphate as the soil was deficient in phosphorus. There was almost 50 per cent increase in rhizome yield when P was applied with FYM. Beneficial effect of FYM on rhizome yield may be due to increased availability of P through FYM as FYM helps in complexing Fe and Al and thus reducing P fixing capacity (Tisdale *et al.* 1990). Similar increase in rhizome yield of turmeric with FYM was also reported by Balashanmugam *et al.* (1989).

Table 1. Effect of P sources and FYM on yield, quality, nutrient uptake and PUE in turmeric

Treatment	Dry rhizome yield (q ha^{-1})	Curcumin (%)	N uptake (q ha^{-1})	P uptake (kg ha^{-1}) Rhizome	Leaf	Total	K uptake (q ha^{-1})	P use efficiency (%)
T_1 Control	11.20	4.28	10.97	2.24	0.89	3.13	15.35	-
T_2 FYM@10 t ha^{-1}	18.93	5.50	23.10	4.54	1.89	6.44	35.51	-
T_3 RP@100 kg P_2O_5 ha^{-1}	31.33	4.98	36.97	6.58	4.07	10.65	66.42	17.1
T_4 T_3 + FYM	44.67	5.80	68.34	8.51	6.70	15.21	98.28	27.4
T_5 SSP @ 100 kg P_2O_5 ha^{-1}	28.67	4.81	36.41	6.02	3.44	9.46	38.12	14.4
T_6 T_5+ FYM	44.80	5.43	69.00	8.54	6.27	14.81	62.72	26.5
T_7 RP+SSP(1:3)	38.27	5.13	47.42	8.04	5.36	13.40	73.09	23.3
T_8 T_7+ FYM	45.73	6.02	70.75	12.89	11.56	24.45	93.75	48.4
T_9 RP+SSP(1:1)	26.67	5.09	34.93	6.93	4.00	10.93	48.00	17.7
T_{10} T_9+FYM	46.00	5.58	68.54	11.88	8.28	20.16	86.02	38.7
T_{11} RP+SSP(3:1)	27.73	5.36	30.78	6.66	3.60	10.26	46.04	16.2
T_{12} T_{11}+FYM	45.07	5.63	61.29	9.52	8.56	18.08	95.54	33.9
C.D. (P=0.05)	6.77	0.82	9.77	1.79	3.17	2.79	12.00	-

Curcumin content of rhizomes also significantly increased by FYM application and highest content (6.02 %) was recorded in RP + SSP (1:3) + FYM treatment which was at par with other P treatments applied with FYM. FYM, in addition to supplying the essential plant nutrients, might have also stimulated all the enzymes, hormones and growth regulators necessary for the synthesis of curcumin. Kumar *et al.* (1992) also reported that increased application of organic manures would result in increased curcumin content of rhizomes.

Nutrient uptake and P use efficiency (PUE)

N, P and K uptake by turmeric increased significantly in all the treatments when compared to control (Table 1). Maximum N and P uptake (70.75 and 24.45 kg ha^{-1}, respectively) were recorded in RP+SSP (1:3) + FYM treatment whereas, K uptake was maximum (98.28 kg ha^{-1}) with RP + FYM which was at par with RP + SSP (1:3) + FYM and RP + SSP (3:1) + FYM. Increase in N, P and K uptake with P and FYM application might be due to improvement in soil physical environment favouring better root growth which in turn enabled the plants to absorb more nutrients from soil.

Phosphorus use efficiency (PUE) ranged between 14.4 to 48.4 per cent and was maximum in RP + SSP (1:3) + FYM treatment followed by RP + SSP (1:1) + FYM. PUE was higher when RP and SSP combinations were applied with FYM as compared to their individual application with or without FYM. The increase in PUE with application of FYM was due to more availability of P to the crop. Similar results were reported by Sharma & Tripathi (1999). PUE of RP was better than SSP when applied alone or with FYM which might be due to high rate of P fixation of water soluble P in SSP and slow release of available P from RP in highly acidic soil throughout the plant growth.

Residual soil properties

The effect of phosphorus sources on post harvest soil properties is presented in Table 2. There was a marginal decrease in soil pH due to FYM application, which might be due to organic acids produced during decomposition of organic matter (Das *et al.* 1991). The effective cation exchange capacity (ECEC), a measure of actual CEC of acid soils in natural field conditions, also increased due to addition of P and FYM over control. This might be due to addition of basic cations

Table 2. Effect of phosphorus sources on post harvest soil properties

Treatment	pH	Organic carbon (%)	ECEC [cmol (p+) kg^{-1}]	Available P (ppm)
T_1 Control	4.47	1.40	3.37	3.09
T_2 FYM@10 t ha^{-1}	4.49	1.58	3.77	3.20
T_3 RP@100 kg P_2O_5 ha^{-1}	4.50	1.51	3.92	3.45
T_4 T_3 + FYM	4.32	1.73	5.30	4.97
T_5 SSP @ 100 kg P_2O_5 ha^{-1}	4.56	1.50	4.29	3.15
T_6 T_5 + FYM	4.54	1.70	4.55	3.88
T_7 RP + SSP(1:3)	4.67	1.52	4.75	4.07
T_8 T_7 + FYM	4.66	1.84	4.56	4.23
T_9 RP + SSP(1:1)	4.77	1.53	4.64	3.98
T_{10} T_9 + FYM	4.61	1.73	4.94	4.83
T_{11} RP + SSP(3:1)	4.61	1.50	4.09	3.61
T_{12} T_{11} + FYM	4.58	1.65	4.17	4.52
C.D. (P=0.05)	NS	0.10	NS	0.20

through added fertilizers and manure. However, the increase in ECEC was statistically non-significant. Organic carbon content increased due to addition of FYM in all the sources of P. Available P in the post harvest soil also increased due to P and FYM application, which might be due to increased availability of phosphate by chelating the phosphate fixing cations (Fe^{3+}, Al^{3+}) and exchange of adsorbed PO_4^{3-} by organic anions (Stevenson 1982).

The above results, thus, indicated that RP+SSP (1:3) @ 100 kg P_2O_5 ha^{-1} along with FYM @ 10 t ha^{-1}, was the best source with maximum PUE, curcumin content and nutrient uptake by turmeric in acidic Alfisols of Meghalaya.

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